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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

Ex parte MIROSLAV TRAJKOVIC

Appeal 2007-3332
Application 09/854,119
Technology Center 2600

Decided: March 5, 2008

Before KENNETH W. HAIRSTON, JOHN A. JEFFERY, and MARC S. HOFF, *Administrative Patent Judges*.

JEFFERY, *Administrative Patent Judge*.

DECISION ON APPEAL

1 Appellant appeals under 35 U.S.C. § 134 from the Examiner's rejection of claims 1-20. We have jurisdiction under 35 U.S.C. § 6(b). We affirm.

STATEMENT OF THE CASE

Appellant invented a method for tracking target objects in images provided from a non-stationary camera that employs motion estimation and compensation techniques. Specifically, low resolution images are computed from two consecutive image frames. Feature points are determined and matched between the two low resolution images. Statistical techniques determine a homography matrix describing motion between the corresponding feature points in the original images, and this matrix is used to align the original images. Differences between aligned images are identified to indicate movement of one or more objects in the image.[1] Claim 1 is illustrative:

1. A method of aligning a first image to a second image, comprising:

determining a first alignment approximation, based on distances between one or more points in the first image and the second image, with the first and second images at a first resolution,

aligning the second image to the first image, based on the first alignment approximation, to form an initially aligned second image,

determining a second alignment approximation, based on the distances between one or more points in the first image and the initially aligned second image, with the first and second images at a second resolution different from the first resolution, and

aligning the second image to the first image, based on the combination of the first and second alignment approximations.

The Examiner relies on the following prior art references to show unpatentability:

[1] *See generally* Spec. 3:1-15.

Frazier	US 5,651,075	Jul. 22, 1997
Gupta	US 5,848,121	Dec. 8, 1998

Claims 1-20 stand rejected under 35 U.S.C. § 103(a) as unpatentable over Gupta and Frazier.

Rather than repeat the arguments of Appellant or the Examiner, we refer to the Briefs and the Answers[2] for their respective details. In this decision, we have considered only those arguments actually made by Appellant. Arguments which Appellant could have made but did not make in the Brief have not been considered and are deemed to be waived. *See* 37 C.F.R. § 41.37(c)(1)(vii).

OPINION

Independent Claim 1

In rejecting claims under 35 U.S.C. § 103, it is incumbent upon the Examiner to establish a factual basis to support the legal conclusion of obviousness. *See In re Fine*, 837 F.2d 1071, 1073 (Fed. Cir. 1988). In so doing, the Examiner must make the factual determinations set forth in *Graham v. John Deere Co.*, 383 U.S. 1, 17 (1966).

Discussing the question of obviousness of a patent that claims a combination of known elements, *KSR Int'l v. Teleflex, Inc.*, 127 S. Ct. 1727 (2007), explains:

> When a work is available in one field of endeavor, design incentives and other market forces can prompt variations of it, either in the same field or a different one. If a person of ordinary skill can implement a predictable variation, §103

[2] We refer to the Answer mailed April 18, 2005 and the Supplemental Answer mailed October 4, 2005.

> likely bars its patentability. For the same reason, if a technique has been used to improve one device, and a person of ordinary skill in the art would recognize that it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond his or her skill. *Sakraida* [*v. AG Pro, Inc.,* 425 U.S. 273 (1976)] and *Anderson's-Black Rock*[*, Inc. v. Pavement Salvage Co.*, 396 U.S. 57 (1969)] are illustrative—a court must ask whether the improvement is more than the predictable use of prior art elements according to their established functions.

KSR, 127 S. Ct. at 1740. If the claimed subject matter cannot be fairly characterized as involving the simple substitution of one known element for another or the mere application of a known technique to a piece of prior art ready for the improvement, a holding of obviousness can be based on a showing that "there was an apparent reason to combine the known elements in the fashion claimed." *Id.* at 1740-41. Such a showing requires "some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness. . . . [H]owever, the analysis need not seek out precise teachings directed to the specific subject matter of the challenged claim, for a court can take account of the inferences and creative steps that a person of ordinary skill in the art would employ." *Id.* at 1741 (quoting *In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006)).

If the Examiner's burden is met, the burden then shifts to the Appellant to overcome the prima facie case with argument and/or evidence. Obviousness is then determined on the basis of the evidence as a whole and the relative persuasiveness of the arguments. *See In re Oetiker*, 977 F.2d 1443, 1445 (Fed. Cir. 1992).

Regarding independent claim 1, the Examiner's rejection essentially finds that Gupta teaches an image alignment method with every claimed

feature but does not explicitly state that images are aligned based on the combination of first and second image approximations. Although the Examiner assumes that Gupta combines the opacified and mask images, the Examiner nevertheless cites Frazier as teaching combining image approximations by applying a Laplacian operator, and concludes that it would have been obvious to one of ordinary skill in the art at the time of the invention to incorporate this teaching into Gupta's system (Ans. 14-15).

Appellant argues that Gupta does not teach or suggest, among other things, determining the first and second alignment approximations based on the recited distances between points in the first and second images as claimed. Rather, Appellant contends, Gupta determines match points within the mask and opacified images. Then, an image-to-image transform is generated that is repeatedly used. Appellant adds that Frazier's processing (edge enhancement and shadow reduction) is performed on a single image, but the reference does not teach manipulating, enhancing, or aligning multiple images (App. Br. 5-10; Reply Br. 2-7).

The Examiner notes that the recited first and second alignment approximations are equivalent to Gupta's match point generation technique which proceeds hierarchically from the lowest resolution to a highest resolution. According to the Examiner, these alignment approximations are based on distances between one or more points in the mask and opacified images (Ans. 3, 5; Supp. Ans. 1-3).

The issue before us, then, is whether the collective teachings of Gupta and Frazier teach or suggest the limitations of independent claim 1, namely the first and second alignment approximation determinations and image alignment steps. For the following reasons, we find that the

collective teachings of the references would have reasonably suggested these limitations.

Gupta discloses a method for digital subtraction angiography (DSA) -- a known procedure for observing vasculature. In a known DSA method, X-ray images are taken before and after an X-ray contrast agent is injected into the blood vessels to produce the mask and opacified images, respectively. Subtracting the mask image from the opacified image should remove all but the image data associated with the opacified blood vessels, but nonetheless can produce artifacts due to, among other things, patient motions and hysteresis (Gupta, col. 1, l. 10 - col. 2, l. 15).

To minimize these artifacts, Gupta's method obtains sub-pixel registration of the mask and opacified images by first implementing a match point generation technique 14 as shown in Figure 1 (Step 14). This technique derives a set of two-dimensional points in the mask image and their corresponding points in the opacified image (Gupta, col. 3, ll. 1-4). Following match point generation, locally-adaptive image-to-image warp generation 16 is performed in which the matched points in the mask image are mapped to corresponding points in the opacified image (Gupta, col. 3, ll. 11-19; Fig. 1 (Step 16)). Then, the logarithm of each pixel value in the transformed (warped) image is subtracted from the logarithm of the corresponding pixel values in opacified image to produce the resulting DSA image (Gupta, col. 3, ll. 20-26; Fig. 1 (Steps 18 and 20)).

The match point generation technique 14 is further detailed in Figure 2. First, an image hierarchy of various resolutions is created to accelerate the generation of match points (Gupta, col. 3, ll. 35-42; Fig. 2, Step 54). The matching process then begins with the lowest resolution image and progresses

to the highest resolution image (Gupta, col. 3, ll. 44-46). To this end, a small tile of imagery around a point in the mask image is correlated with all tiles in the opacified image -- a technique that proceeds hierarchically from the lowest to highest resolution images. The center of the tile in the opacified image that gives the maximum correlation is identified as the corresponding match point (Gupta, col. 3, ll. 52-62).

Once a set of match points is computed, an image-to-image transform is generated for registering the image tiles between the mask and opacified images (Gupta, col. 4, ll. 7-10; Fig. 2, Step 60). The matching process is then repeated using this new transform, ultimately resulting in a grid of match points in the mask image and their corresponding match points in the opacified image (Gupta, col. 4, ll. 7-18; Fig. 2, Step 62).

Then, a suitable displacement (dx, dy) is determined by interpolation that is added to each grid point in the mask image to find the coordinates of the corresponding point in the opacified image. Thus, each pixel's location in the mask image is transformed by interpolation to find the location of the corresponding pixel in the opacified image. Then, the intensity of each pixel in the mask image is log-subtracted from the corresponding pixel in the opacified image (Gupta, col. 4, ll. 19-46).

Based on this functionality, we agree with the Examiner (Ans. 3; Supp. Ans. 1-2) that the repetitive matching process in Gupta's match point generation technique that proceeds from lower to higher resolutions reasonably corresponds to the recited first and second alignment approximations, respectively. In our view, correlating particular areas of the mask image with corresponding areas of the opacified image reasonably constitutes an "alignment approximation" when the term is given its broadest reasonable interpretation.

Furthermore, we find that these alignment approximations are based, at least in part, on distances between corresponding points in the respective images. In this regard, we note that Gupta expressly states that the image tiles in the mask and opacified images may be rotated or *translated* with respect to each other -- a mismatch that is corrected by a transformation based on user-provided match points (Gupta, col. 3, ll. 63 - col. 4, l. 2; emphasis added). In view of this displacement between the corresponding areas in the mask and opacified images -- a displacement that would clearly involve distances between these corresponding points -- the correlation between these corresponding areas in Gupta's match point generation technique (i.e., the "first alignment approximation") would therefore be based on, at least in part, this displacement.

We also find that the image-to-image transform generated based on the determined match points (i.e., Step 60 in Fig. 2) reasonably corresponds to the recited alignment steps. Significantly, Gupta indicates that the image-to-image transform is for *registering* the image tiles between the mask and opacified images (Gupta, col. 4, ll. 7-10). The term "register" is defined, in pertinent part, as "[t]o adjust so as to be properly aligned" and, alternatively, "[t]o be in proper alignment."[3] Based on these facts, skilled artisans would readily understand that

[3] The American Heritage Dictionary of the English Language, 4th ed., 2000, *available at* http://www.bartleby.com/61/55/R0125500 (last visited Feb. 21, 2008). Although Appellant contends that the terms "aligned," "aligning," and "alignment" are "clearly defined" in the Specification (App. Br. 9-10), we do not find an express definition in the Specification tantamount to a special definition of the terms. Accordingly, absent a specific definition, we construe the terms with their plain meaning (i.e., the ordinary and customary meaning given to the terms by those of ordinary skill in the art). *See Brookhill-Wilk 1, LLC. v. Intuitive Surgical, Inc.*, 334 F.3d 1294, 1298 (Fed. Cir. 2003); *see also Phillips v. AWH Corp.*, 415 F.3d 1303, 1312 (Fed. Cir. 2005) (en banc).

the image-to-image transform in Gupta effectively provides an alignment function at least with respect to the corresponding image tiles in the mask and opacified images. Therefore, the image-to-image transform created at a lower resolution reasonably corresponds to "aligning the second image to the first image" at least in part -- an alignment that is "based on" the generated match points that correspond to the recited first alignment approximation. Likewise, the alignment approximation and image-to-image transform determined at the higher resolution (i.e., following the lower resolution determinations) reasonably corresponds to the second alignment approximation and alignment steps.

Although we find the Examiner's reliance on Frazier problematic for teaching that the second alignment step is based on the combination of the first and second alignment approximations (Ans. 4, 5, 15; Supp. Ans. 3) essentially for the reasons indicated by Appellant (App. Br. 6-10; Reply Br. 4, 6, 7),[4] we nonetheless find that Gupta reasonably teaches this limitation. In our view, the *iterative, sequential* generation of image-to-image transforms in Gupta's match point generation technique (i.e., Steps 56-62 of Figure 2) effectively results in

[4] However, we note in passing that Appellant's contention that the Examiner's reliance on various aspects of Frazier as allegedly constituting an improper new grounds of rejection is not an appealable matter, but rather a petitionable matter, and is therefore not before us. *See* MPEP § 1207.03(IV) (noting that if Appellant believes that an Examiner's Answer contains a new ground of rejection not identified as such, Appellant may file a petition under 37 C.F.R. § 1.181(a) within two months from the mailing of the Examiner's Answer); *see also* MPEP § 706.01 ("[T]he Board will not hear or decide issues pertaining to objections and formal matters which are not properly before the Board."); MPEP § 1201 ("The Board will not ordinarily hear a question that should be decided by the Director on petition….").

multiple sequential alignments that are based, at least in part, on the corresponding determined match points. Significantly, these sequential determinations are iterative. Thus, image-to-image transforms that are iteratively determined at higher resolutions would be based on, at least in part, the current and previous match point determinations (i.e., the combination of alignment approximations determined at higher and lower resolutions).

For the foregoing reasons, we find that Appellant has not persuasively rebutted the Examiner's prima facie case of obviousness based on the collective teachings of Gupta and Frazier. Accordingly, the Examiner's rejection of that claim is sustained.

Claims 2 and 3

We will also sustain the Examiner's rejection of claim 2, calling for aligning the initially aligned second image based on the second alignment approximation, essentially for the reasons indicated in connection with claim 1 above. We therefore incorporate that discussion here by reference.

Regarding claim 3, we will also sustain the Examiner's rejection of that claim for similar reasons. Furthermore, we disagree with Appellant's contention (App. Br. 12) that the opacified image in Gupta only has a single resolution as compared to the multiple mask images. On the contrary, Gupta expressly states that when the image hierarchy is created in connection with match point generation (i.e., Step 54 in Figure 2), *both images* (i.e., the mask and opacified images) are successively reduced to half their size and resolution via subsampling (Gupta, col. 3, ll. 39-42; col. 6, ll. 1-5 (text of claim 4)).

For the foregoing reasons, Appellant has not persuasively rebutted the Examiner's prima facie case of obviousness for claims 2 and 3. The Examiner's rejection of those claims is therefore sustained.

Claim 4

We will also sustain the Examiner's rejection of claim 4 calling for applying the RANSAC algorithm. We agree with the Examiner (Ans. 7; Supp. Ans. 5-6) that such algorithms are well known -- a fact evidenced by Appellant's own Specification.[5] In our view, using such well-known algorithms that identify and ignore inconsistent points in a set in the image processing system of Gupta would have been tantamount to the predictable use of prior art elements according to their established functions -- an obvious improvement. *See KSR*, 127 S. Ct. at 1740. The rejection is therefore sustained.

Claim 5

We will also sustain the Examiner's rejection of claim 5 essentially for the reasons indicated in connection with claim 1. As we indicated previously, Gupta expressly states that the image tiles in the mask and opacified images may be *rotated* or *translated* with respect to each other -- a mismatch that is corrected by a transformation based on user-provided match points (Gupta, col. 3, ll. 63 - col. 4, l. 2; emphasis added). This feature, in our view, amply suggests that the rotation and translation components are approximated at least to correct the mismatches resulting therefrom. For the foregoing reasons,

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[5] Appellant's Specification states that "[t]he RANSAC algorithm, *common in the art,*...identifies and ignores 'outliers', points in a set of sample point [sic] that are inconsistent with most of the other points in the set" (Spec. 6:23-25; emphasis added).

Appellant has not persuasively rebutted the Examiner's prima facie case of obviousness for claim 5 and the rejection is therefore sustained.

Claims 6 and 7

We will also sustain the Examiner's rejection of claims 6 and 7 which call for, in pertinent part, a 3x3 homographic matrix. The Examiner indicates that methods involving homographic matrices are well known in the art (Ans. 8; Supp. Ans. 6). Appellant does not dispute this position, but rather argues that the Examiner has simply restated functions performed by the cited references and has not shown how a 3x3 homographic matrix would be used in the cited references to determine alignment approximations (App. Br. 15-16; Reply Br. 9-10).

Based on the record before us, we see no reason why skilled artisans could not have employed such a matrix to perform the alignment approximations in Gupta. Clearly, Gupta's match point generation technique uses multiple coordinates associated with the respective points in the respective images. In our view, to use known homographic matrix techniques to process data and render the calculations associated with these points in Gupta's image processing system would have been tantamount to the predictable use of prior art elements according to their established functions. *See KSR*, 127 S. Ct. at 1740. We will therefore sustain the Examiner's rejection of claims 6 and 7.

Claim 8

We will also sustain the Examiner's rejection of claim 8. Although Gupta does not expressly indicate that corners are identified based on a determination of Minimum Intensity Changes as claimed, Gupta does state that

a *feature-based* matching scheme could be used in lieu of a correlation-based scheme (Gupta, col. 4, ll. 56-58; emphasis added). Furthermore, Appellant's own Specification admits that Minimum Intensity Change (MIC) corner detectors are well known in the art (Spec. 8:11-19).

Based on these teachings, we see no reason why skilled artisans could not have utilized a conventional feature-based scheme, such as MIC corner detection, in Gupta. In view of Gupta's teaching of using feature-based matching schemes, incorporating a conventional corner detection scheme in Gupta is tantamount to the predictable use of prior art elements according to their established functions -- an obvious improvement. *See KSR*, 127 S. Ct. at 1740. We will therefore sustain the Examiner's rejection of claim 8.

Claims 9, 12, 13, 15, and 18-20

We will also sustain the Examiner's rejection of independent claim 9 calling for, among other things, tracking an object based on first and second images by detecting motion by comparing the set of aligned images. At the outset, we note that our previous discussion pertaining to claim 1 applies equally here and we incorporate that discussion by reference. Furthermore, we agree with the Examiner (Ans. 9) that Gupta, in effect, detects motion as claimed. In connection with match point generation, Gupta states that a grid of points in the mask image is *square*, but the grid in the opacified image is *not square* due to, among other things, patient motion (Gupta, col. 4, ll. 14-18).

The clear import of this discussion is that comparing the respective shapes of the grids associated with the mask and opacified images in Gupta can determine whether patient motion exists -- and therefore detect such motion. That is, if the grids in the mask and opacified images were both square, then no

motion would be detected. But if the grids had different shapes, then the system would detect motion, hysteresis, or other such effects. Although we recognize that motion would not necessarily be detected by this comparison due to the possible existence of hysteresis and other such effects, Gupta nevertheless strongly suggests that patient motion would be detected by the system if it were present.

Regarding claims 12 and 18, we add that the location of the points in the grids in the mask and opacified images is also determined, and that such a determination effectively determines a location of the object (i.e., that part of the patient). Comparing the respective grids' shape in Gupta as noted above thus involves comparing the location of the object in each image as claimed.

For the foregoing reasons, we find that Gupta's system, in effect, tracks an object (the patient) and detects motion by comparing aligned images as claimed. The Examiner's rejections of claims 9 and 12 are therefore sustained. Likewise, we will sustain the Examiner's rejection of independent claim 13 for similar reasons as claim 13 recites commensurate limitations. Since Appellant has not separately argued the patentability of dependent claim 15, it falls with independent claim 13. *See* 37 C.F.R. § 41.37(c)(1)(vii).

Regarding claims 19 and 20, our previous discussion pertaining to claims 5-7 above applies equally here and we incorporate that discussion by reference.

Claims 10 and 14

We will also sustain the Examiner's rejection of claims 10 and 14 for the same reasons as we indicated with respect to claim 3 above, and we therefore

incorporate that discussion by reference. The rejections of claims 10 and 14 are therefore sustained.

Claim 11

We will also sustain the Examiner's rejection of claim 11. At the outset, we reiterate that Gupta teaches that a *feature-based* matching scheme could be used in lieu of a correlation-based scheme (Gupta, col. 4, ll. 56-58; emphasis added). In our view, skilled artisans would readily recognize that such features could include color.

Although Gupta does not say what colors are present in the X-ray images processed by that system, we agree with the Examiner (Ans. 10) that skilled artisans would recognize that typical X-ray images contain at least gray, black, and white. Appellant's argument that gray, black, and white are not colors (App. Br. 20-21; Reply Br. 11-12) is unavailing. Although black and white are not within the visible color spectrum (i.e., they are not elementary colors), black and white nonetheless comprise colors. Specifically, white can be produced by combining all three primary "additive colors" (red, green, and blue-violet). Likewise, mixing three primary "subtractive colors" (magenta, yellow, and cyan (blue-green)) yields black.[6] And even if gray is simply a mixture of black and white as Appellant argues, skilled artisans would readily recognize that gray would effectively constitute a mixture of the additive and subtractive colors of both white and black as noted above.

Therefore, even assuming that X-ray images contained solely white, black, and gray and identification was based solely on matching these

[6] *See* "Color," *in* The Columbia Encyclopedia, 6th ed., *available at* http://www.bartleby.com/65/co/color.html (last visited Feb. 21, 2008).

pigments, such matching would still fully meet "color matching" as white, black, and gray each comprise colors. In any event, we add that extending the ability to match white, black, and gray to matching other colors would have been well within the level of skilled artisans. "A person of ordinary skill is also a person of ordinary creativity, not an automaton." *See KSR*, 127 S. Ct. at 1742.

For the foregoing reasons, we will sustain the Examiner's rejection of claim 11.

Claim 16

We will also sustain the Examiner's rejection of claim 16. We agree with the Examiner (Ans. 11-12) that Gupta's system must have at least a temporary memory for storing a representation of a target image. We reach this conclusion noting that the purpose of Gupta is to ultimately render a DSA image with reduced artifacts by subtracting the transformed mask image from the opacified image. Further, nothing in the claim precludes the identified "target" to constitute the pixel intensity values of the mask image that are log-subtracted from the corresponding pixels in the opacified image. This target identification would be based, at least in part, on a "representation of a target image" in the form of a stored log-subtraction algorithm or process and the values used by such a process.

For the foregoing reasons, we will sustain the Examiner's rejection of claim 16.

Claim 17

We will also sustain the Examiner's rejection of claim 17 for the same reasons as we indicated previous in connection with claim 11. We therefore incorporate that discussion here by reference.

DECISION

We have sustained the Examiner's rejection with respect to all claims on appeal. Therefore, the Examiner's decision rejecting claims 1-20 is affirmed.

No time period for taking any subsequent action in connection with this appeal may be extended under 37 C.F.R. § 1.136(a)(1)(iv).

AFFIRMED

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